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Abstract Does the existence of body representations undermine the explanatory role of the body? Or do certain types of representation depend so closely upon the body that their involvement in a cognitive task implicates the body itself? In the introduction of this special issue we explore lines of tension and complement that might hold between the notions of embodiment and body representations, which remain too often neglected or obscure. To do so, we distinguish two conceptions of embodiment that either put weight on the explanatory role of the body itself or body representations. We further analyse how and to what extent body representations can be said to be embodied. Finally, we give an overview of the full volume articulated around foundational issues (How should we define the notion of embodiment? To what extent and in what sense is embodiment compatible with representationalism? To what extent and in what sense are sensorimotor approaches similar to behaviourism?) and their applications in several cognitive domains (perception, concepts, selfhood, social cognition).

Cognitive science of the last 20 years has seen an increasing focus on the body. Embodied cognitive science has become an industry. However, its unity is questionable (Clark 2008a, b), and its status as a competitor or ancestor to traditional cognitive science is unclear (for divergent views compare Thagard 2005; Varela et al. 1991). Still, a worry shared by many is that classical cognitive science puts too much of the mind's cognitive resources in the head. In its most radical form, this worry leads to a

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rejection of the traditional notion of internal representation. Representations are thought to be inefficient because they are computationally too costly; they are thought to be unnecessary because real biological systems dynamically interact with that which was traditionally thought to be represented (Chemero 2009; Gallagher 2008; Thelen and Smith 1994; Turvey and Carello 1995; Van Gelder 1995). This latter claim may be especially true of the body (Kinsbourne 1995, 2002); modifying an expression coined by Brooks (1991), perhaps "the [body] is its own best model". The amount of information received from the body is quantitatively superior to that received from any environmental object: not only can we see and touch it, we also receive a continuous flow of proprioceptive and interoceptive inputs. As Merleau-Ponty (1945/1962) notes, the body presents a highly special feature compared to any other object in the world: it never leaves us; why do we then need an internal representation of the body? If real biological systems will only know what they need to in order to get the job done (Clark 1989, pp. 64–66), is the body really something that the brain needs to "know" in this sense?

In notable ignorance of questions such as these, body representations have become the stock in trade of much recent cognitive psychology, neuroscience, and empirically sensitive phenomenology and philosophy of mind. Certainly, arguments in favour of retaining representations within the cognitive scientist's toolkit can be levied in favour of the increasing frequency in which body representations are posited. But a more poignant (and perhaps fruitful) point of focus, independent of the general issue of whether cognitive systems represent *tout court*, is whether positing body representations actually undermines the explanatory role of the body, in the same manner in which positing representations of the world has been thought to undermine the explanatory role of the environment (cf. Brooks 1991). Alternatively, perhaps certain types of representation are so closely dependent upon the non-neural body (i.e. the body besides the brain), that their involvement in a cognitive task implicates the non-neural body itself. The relationship between embodied theories and body representations remains obscure, yet an increasing number of researchers appeal explicitly to body representation and embodiment interchangeably (Arzy et al. 2006; Chatterjee 2010; Gallese and Sinigaglia 2010, 2011; Glenberg 2010; Goldman and de Vignemont 2009; Marasco et al. 2011; Meteyard et al. 2012; Newport et al. 2010; Pezzulo et al. 2011). We believe the time is ripe to explore lines of tension and complement that might hold between these notions.

1 Strong and Weak Embodiment

In an early, somewhat field-defining treatment Clark (1997, pp. 148–149) distinguished "radical embodied cognitive science", with its paradigm-shifting wholesale denial of representational cognitive scientific explanation (Kelso 1995; Port and van Gelder 1995; Thelen and Smith 1994; Van Gelder 1995; though see Chemero 2009, pp. 28–33), from a less radical embodied cognitive science that liberally employs both representational and non-representational explanatory schemes (Clark 1997; Wilson 2004). The core issue between 'radical' and 'moderate' embodied cognitive science is not between contrasting notions of embodiment per se; rather, it concerns the presence or absence of representations in cognitive systems. There are, however, at least two notions of embodiment operative in the literature. According to Prinz, to say of some cognitive phenomenon, or some aspect of mind, that it is embodied, means either that it "depends on the possession and use of a body, not just a brain" or that it depends on "mental representations or processes that relate to the body" (2009, p. 420). Though *prima facie* these ideas might seem "related in spirit" (Clark 1997, p. 242), note that only the former (*sc.* dependence upon the body) threatens to rock the neurocentric 'applecart' of modern cognitive science (Block 2007). To keep track of this difference, we will call any view that gives a clear explanatory role to the body a 'strongly embodied' view (or 'strong embodiment'); by contrast, we will call any view that gives a clear explanatory role to representations of the body, whilst *not* also giving a clear explanatory role to the body itself, a 'weakly embodied' view (or 'weak embodiment').[1]

In contrast to the distinction between radical and moderate embodied cognitive science, the strong/weak dichotomy is really is a distinction between different conceptions of embodiment. Moreover, strong embodiment is perfectly compatible with the pluralistic ends of moderate theorists: a strongly embodied view can still appeal to representations, even representations of the body, provided that the body itself is given a clear explanatory role. Still, this bare possibility makes it no less important to be clear whether it is reference to the body itself, or representation of the body, that is thought to aid an explanation of some cognitive phenomenon; for in certain cases there might be two competing accounts of the same phenomenon, one appealing to weak embodiment and the other appealing to strong embodiment. Equivocation in this regard is easily invited by the use of ambiguous terms like 'body schema'. Thus, for instance, Menary writes: "The body is integrated with the environment through its body schemas, which are unconscious sensorimotor programs for action" (Menary 2010, p. 233). In the mainstream neuroscientific usage, the term 'body schema' typically refers to an internal representational process of integrating sensorimotor information to enable holistic motor control (de Vignemont 2010), rather akin to Menary's "sensorimotor programs", implicating weak embodiment at most (cf. also Clark 2008c, pp. 37–39). By contrast, Shaun Gallagher's phenomenologically inspired use of the term refers to a strongly embodied sensorimotor process, strongly embodied in so far as it is clearly intended to include peripheral sensory organs and effectors in the channelling and structuring of information flow (Gallagher 2005a, b). This is a clear instance in which the contrast between strong embodiment and body representation presents a real tension. For it seems that two divergent referents of a term are each singled out as providing adequate explanation of a phenomenon. In the mainstream neuroscientific usage, the body schema *qua* body representation serves to explain the phenomenon of holistic bodily movement; in the

[1] Our use of the term "strong embodiment" is similar to that in Dempsey & Shani (forthcoming) article, though his central concern is with distinguishing strong embodiment (or "strong embodied cognitive science") from the form of extended functionalism proposed by Clark (2008a, b) (see also Jacob, this volume). The term "strong embodiment" is also used in Chatterjee (2010) and Meteyard et al. (2012), but in a manner wholly divergent from both Dempsey & Shani's and our own. In both Chatterjees and Meteyard et al.'s discussion, a "strongly embodied" view is committed to the claim that conceptual processing activates precisely the neural perceptual and motor structures that were engaged in the original perceptual and motor experiences involved in instances of the relevant concepts; views are "disembodied" or more "weakly embodied" to the extent that they depart from such a commitment. On our use of the strong/weak distinction (and likely, Shani's), both Chatterjee and Meteyard et al.'s reviews limit their scope to weak embodiment.

phenomenologically inspired approach, the body schema *qua* strongly embodied process serves to explain the phenomenon of holistic bodily movement.

2 Weak Embodiment and Disembodiment

Reviews of the “embodiment” literature abound, but few keep track of the very basic difference between strong and weak embodiment. Some focus exclusively on weak embodiment (e.g., Mahon and Caramazza 2005), others focus on more general themes in which the ideas are clearly “related in spirit”; Margaret Wilson’s (2002) timely and widely cited review is exemplary in this latter respect. She distinguishes no less than six themes that characterise the embodied cognitive science movement: (i) cognition is situated; (ii) time-pressured; (iii) we off-load cognitive work onto the environment; (iv) the environment is part of the cognitive system; (v) cognition is for action; (vi) offline cognition is body based. Most of these themes do not heed the distinction at hand. Rather for the most part they emphasise the putatively “situated”, “distributed” or “extended” nature of cognition. The principal issues here do not concern embodiment *per se*, rather they concern the constraints and opportunities posed by the environment and our active engagement with it, and the implications that this might have for the nature and extent to which internal representation of the environment is required. For instance, Wilson’s fifth theme (cognition is for action) might seem *prima facie* to bear upon a specific notion of embodiment, but in fact the main focus of work in this area is that the manner in which cognitive systems *represent the world* is much more sparse, task-specific and fleeting than might classically have been thought (Ballard et al. 1997; Churchland et al. 1994; Glenberg 1997). The explanatory role of the body, or indeed its representation, is hardly clear; if indeed it is implicated at all.

In fact the only theme in Wilson’s review that actually touches on either strong or weak embodiment (the latter in particular) is that indicated by her claim that “off-line cognition is body based”. She considers the example of gradually internalising a well-known cognitive scaffold, counting on one’s fingers; perhaps the familiar articulated movements could be replaced by mere twitches, and those might even be replaced by covert motor activation. She concludes: “If this kind of mental activity [*sc.* covert motor activation] can be employed successfully to assist a task such as counting, a new vista of cognitive strategies opens up” (Wilson 2002 p. 633). The possibility of such a gradual internalisation opens up a range of possibilities for representations of the body to play the same functional role in a task as the overt bodily movements internalised. Moreover, research in this line–on memory (Glenberg 1997), conceptual understanding (Lakoff and Johnson 1999), and the relationship between conceptual processing and sensorimotor processing (Barsalou 1999; Gallese and Lakoff 2005)–certainly comes closest to addressing the more abstract forms of cognition that were thought to be troublesome for embodied cognitive science. But on Wilson’s gloss this is all gained precisely in virtue of the cognitive system’s ability to “decouple” from the body itself (Wilson 2002 p. 633).

As a further example of such decoupling, consider a few observations from the study of intentional bodily movement. In many biological systems (humans especially) peripheral signals specifying the dynamics of bodily movement are ambiguous and cannot travel fast enough to provide timely influence on central motor processes (Latash 2008, pp. 258–260). Nevertheless, smooth sensorimotor control is achieved. According to a well-established, though still controversial (see e.g. Beer 2009; Kelso 2002; Ostry and Feldman 2003; Turvey 1990) line of research in motor control, the explanation is that the brain encodes a model of the musculoskeletal system, using copies of the outflowing motor signals to compute the likely sensory feedback that would be generated by the movements specified (see e.g. Desmurget and Grafton 2000). This enables the system to not only accommodate signal delay and unreliability, but also explore likely changes in the causal process without any obligation to implement such changes. If this is right, then skilful sensorimotor engagement is enabled precisely in virtue of driving a model (often known as a forward model, cf. Miall and Wolpert 1996) of the causal process, alongside or in absence of the actual control process.

This brief sketch frames a set of ideas shared by many psychological, neuropsychological and computational neuroscientific treatments of motor control (Davidson and Wolpert 2005; Jeannerod 1997; Wolpert and Ghahramani 2000). The central idea here can be stated more abstractly in simple control-theoretic terms. Some control systems have only two components: a controller and a plant. Coupling of controller and plant enables a feed-back control system in which the controller receives signals from the output of the plant and sends control signals according to the relative disparity between output and target state. But when feedback is gappy or unreliable, or when the system needs to explore possibilities without implementing them, a third component is necessary: a *model* of the plant. This further complexity to the control architecture enables further possibilities for interaction within the system; the control system can interact with the plant itself, or it can interact with an internal model. With respect to biological systems enabling cognitive states, this second possibility has two rather significant implications. The first is that interactions between the controller and the internal model occur within the brain *as a self-contained system* (Grush 2003, p. 81). The second is that by covertly running a model of the motor control process, the brain (*sans* body) might generate sensory and motor information to support a variety of cognitive functions (Grush 2004; Hesslow 2002; Jeannerod 2006; Kosslyn et al. 1993; Wexler et al. 1998). These latter ideas all seem familiar on the notion of weak embodiment. But note that they are but a hair's breadth away from the (also familiar) neurocentric idea that cognitive states are exclusively realised in neural hardware.

Indeed, within the control-theoretic framework a neurocentric conclusion might be reached by similar but subtly different means. Describing cognitive systems in control-theoretic terms might be especially desirable in allowing one to categorise distinct components and explore quantitative and even qualitative differences in the dynamics of their interaction. From this perspective, one might see differences in "speed of information flow (i.e. bandwidth), and the degree and kind of coupling" as features that distinguish dynamics internal to the brain (i.e. between controller and model) from intra-extra-neural dynamics (i.e. between controller and plant) (Eliasmith 2008, p. 150). If these differences turned out to be important for a particular cognitive function, this might be one basis on which to identify the realisers of that function in a manner that excluded non-neural elements (Clark 2009, pp. 983–987).

3 Action-Orientated Body Representation

The potential for internalisation and decoupling has frequently served in a quasi-evolutionary argument for describing a system as representational (Clark and Grush 1999, p. 7; Dennett 1996, pp. 88–90; Metzinger 2003, pp. 47–49; O'Brien and Opie 2004, pp. 213–276; Smith 1996, pp. 213–276). We hope to have shown that to claim that certain representations are related to the body is one thing, but to explicitly articulate the relation to the body, such that the body nevertheless plays an explanatory role, is another thing entirely. One class of representation thought by many to be particularly suited to embodied cognitive science is that of 'action-centred representation'. Accordingly, a theoretically interesting possibility here would be to explore whether certain representations of the body could be classified as action-centred. But in order for that to be a viable possibility, one needs an answer to the question: what makes a representation action-centred?

We use the term action-centred representation to refer to a family of alternatives to traditional conceptions of mental representation: skill-based representation (Evans 1982; Grush 1998), pushmi-pullyu representations (Millikan 1995), action-orientated representations (Clark 1997; Mandik 2005), non-conceptual representations (Cussins 1990). The common asset of these various notions is that they incorporate intuitions and objections raised by radical embodied cognitive science, but within a representationalist framework. However, despite the frequent invocation of action-centred representation (or something similar), frustratingly little work has been devoted to the articulation of the core features that distinguish it from other forms of representation. We believe, at minimum, that action-centred representations ought to be distinguished from the idea that bodily movement itself can instantiate a process of representing (Rowlands 2006), for the principal attraction of action-centred representation is its association with "partial" or "minimal-memory" schemes of *internal* representation (Ballard et al. 1997; Clark 1997; Wheeler 2005). Furthermore, we believe that the role of representations in action is not a matter of all or nothing. Even highly cognitive states at the personal level can be causal antecedents to action (or at least explanatorily implicated by an action). Let us consider for a moment the following example. A person goes to the kitchen, and intends to do so because she believes that there is chocolate there. It would be tenuous to say that her belief is embodied simply because it plays a causal/explanatory role in her action. Here, and arguably elsewhere, the connection between representation and action is a matter of degree; it is a matter of how direct or immediate the transition is from representation to action. In the case of the person's chocolate belief, the format is not directly exploitable to guide her action. Furthermore, her belief can be used not only to guide her behaviour but also in abstract reasoning. As such, it is not intrinsically action-centred; its function depends on the consumer's use. Finally, one may note that the person's belief does not suffice to trigger her action. It has no motivational dimension, unlike an intention. It does not tell her what is to be done. This brief overview already reveals several related candidates for individuating criteria of action-centred representations: format directly exploitable by action, exclusive use for action, intrinsic action-relatedness, motivational force. Let us focus on a single standard criterion for distinguishing different types of representations, namely, direction of fit.

A classic dichotomy in the philosophical literature is between world-to-mind and mind-to-world direction of fit. In the former case, representations are descriptive states with truth conditions. Belief is a typical example at the personal level. In the latter case, representations are directive states with success conditions. The typical example is then desire. The problem with this dichotomy is that it leaves the way the world is described and the way one acts upon the world quite separated. The notion of pushmipulliu representation (hereafter PPR) introduced by Millikan (1995), also sometimes referred as action-orientated representation (Clark 1997), aims to palliate this deficiency. PPRs combine two directions of fit, from mind-to-world and from world-to-mind. They have thetic and telic structure (Humberstone 1992). They have both truth conditions and success conditions. PPR is more primitive than the combination of a directive representation and a descriptive representation because one has no utility without the other. A typical example can be found in representation of affordances (Millikan 1995). They describe how the environment is arranged while informing how one can move within this environment. There is no need to translate descriptive information into directive information. The same may be said of any visuomotor representation (Jacob and Jeannerod 2003), and of agentive experiences (Bayne 2010).

Now, one way proponents of "embodiment" might want to go is to propose the existence of bodily PPRs, defined as follows: a bodily PPR is any representation that encodes bodily properties in a format that is directly exploitable to guide action. Certainly, the mere fact that some cognitive task involves bodily PPRs hardly implicates a particularly strong notion of embodiment, if it implicates the embodiment of cognition at all. But to infer from the fact that a system is representational that its realisers are solely neural is to confuse strong embodiment with a radical anti-representationalist cognitive science. A natural question then is this: In what way is strong embodiment compatible with the idea that the brain represents its body?

4 Strong Embodiment and Embodied Representation

It has recently been argued that certain properties of internal information bearing structures distinguish them as the kind of representational structures able to support cognitive states (Adams and Aizawa 2001, 2008). Some even go so far as to argue that demarcating the brain as the realiser of cognitive states is adequately justified by the brain's ability to represent, and thus decouple from that which it represents. But from this fact are we entitled to go as far as Grush, who provocatively writes: "The brain can silently contemplate, dream, plan, all as a matter of a play of representations–pretty much everything Descartes thought the mind could do even in absence of the world" (Grush 2003, p. 87); or indeed, in the absence of a body?

Most of the conceptual work involved in rejecting a neurocentric account of cognition has (perhaps too often) been in the service of arguing for the blanket "extension" of cognition. Work in this area is characterised by two "waves" (Menary 2010; Sutton 2010). The first-wave extrapolated functionalist intuitions to argue that whenever one confronts non-neural elements functioning in the same manner as neurocognitive processes, those elements are part of a cognitive process that extends beyond the brain; the famed "parity principle" (Clark and Chalmers 1998). From the functionalist perspective that first-wave arguments assume, "the body, insofar as it is cognitively significant, turns out to be itself defined by a certain complex functional role" (Clark 2008b, p. 56). However, parity arguments might fall short of establishing that a cognitive phenomenon is *necessarily* strongly embodied, if the body is conceived as "just one element in a kind of equal-partners dance between brain, body and world" (ibid.). Clearly this "cognitively significant" functional role might be played by the body, its representation, or some aspect of the local environment. Accordingly, it hardly follows that any view on which cognition is extended is also a view on which cognition is (necessarily, at least) strongly embodied.

Similar problems do not arise with the second-wave, which shifts the focus from "parity" to "complementarity". In complementarity views, non-neural elements find their place in a cognitive system in virtue of both being coordinated with neural processes and providing a *different kind* of functionality from the neural processes involved. This is still broadly compatible with conceiving of the mind in terms of cognitive functions, but it puts pressure on the idea that those functions can be realised by just any old (neural or environmental) material. Interestingly, note that complementarity arguments might well resist the lines of argument sketched in the previous section which some believe to undermine the claim that cognitive systems are embodied. For example, one cannot conclude that non-neural elements are not part of the cognitive system for the mere fact that there are distinctly *neural* information processing profiles (*contra* Clark 2009; Eliasmith 2008). For it might be precisely in virtue of instantiating a *different* information processing profile from neural hardware that the body serves a useful role in the cognitive system. Neither can one conclude that cognitive systems are neurally bound from the premise that certain cognitive functions are enabled by internalising sensorimotor information and decoupling from its source (*contra* Grush 2003; Wilson 2002). Here again, a means of singling out the body as genuinely explanatory would be to show that the body itself is implementing a distinct but complementary process to that provided by neural hardware. For instance, Goldin-Meadow (1999) has argued that gestures might be such a case.

In short, it seems that complementarity arguments, as opposed to parity arguments, are a more likely means to establish strong embodiment. These are surely not the only two options though (see also R. Wilson and Foglia 2011); and indeed complementarity arguments might not be sufficient in and of themselves. One worry might be that even if in some cases the body does implement a complementary information processing profile, there are still cases in which a decoupled system is able to instantiate the very same cognitive process. In order to argue that, in such cases, said cognitive process is still nevertheless strongly embodied, one might argue that the development and maintenance of such a process is dependent upon some other process implemented by the body. However, this kind of dependency is likely to be causal, as a product of development or evolution, and strong claims made on this basis (especially as regards the *constitution* of cognitive processes) remain controversial (for discussion see Adams and Aizawa 2008; Hurley 2010; Shapiro 2010, Chapter 6).

5 Overview of the Volume

We turn now to an overview of the contributions to this special issue. One peculiarity of this volume was that we were not looking for revised manifestos or dismissive criticisms. Rather, each contribution was made with a view to clarifying the concept of embodiment, its productive value and contemporary worth in the study of mind, and its relation to the emerging focus on body representation in contemporary cognitive neuroscience. To this end, we encouraged innovative formats, including debates between opposite views (see O'Regan & Block as well as Gallagher & Povinelli) and synthesis of complementary perspectives (Candidi, Aglioti and Haggard). The main focus of the volume was thus to address foundational issues on embodied cognition.

How Should We Define the Notion of Embodiment? **Alvin Goldman** argues in favour of the existence of bodily codes, which he considers to be the most theoretically and empirically fruitful notion of embodiment. He defines a bodily code as a class of representational format whose primary function is to represent one's bodily states and which can be redeployed for representing other things. The notion of redeployment in bodily format can also be found in **Candidi, Aglioti & Haggard** under the label of embodiment$_3$, which comes in addition to two more basic notions of embodiment that appeal to bodily content, rather than format: embodiment$_1$ defined as the representation of the interoceptive body; and embodiment$_2$ defined as the representation of the multisensory body. On the other hand, **Pierre Jacob's** discussion focuses more on the explanatory role of the body than on notions of embodiment *per se*. He explores two conceptions of embodiment, one in which the explanatory role of the body is no different from that of the local environment, and another that maintains a distinctive contribution is provided by the body that distinguishes an embodied cognitive system from its environment. He argues that the biggest challenge faced by the latter is the intuitive idea that the body functions as a tool in cognitive tasks, which may lead to the same objections as those levied at the extended mind hypothesis.

To What Extent and in What Sense is Embodiment Compatible with Representationalism? As already apparent from a quick overview of the definitions of embodiment, some notions are clearly representational (see e.g., **Goldman's** contribution or **Candidi, Aglioti & Haggard's**) but it is still a matter of debate whether the explanatory role of the body is mediated by representations, and especially representations with a bodily content or format. **Jacob**'s discussion aims at showing the failure of a weak body-centric computationalism. **Cussins** rejects 'cold' referential theories of representation. However, he proposes an alternative type of representation, endowed with what he calls 'hot' mediational content, which can explain embodied skills such as action and navigation.

To What Extent and in What Sense Are Sensorimotor Approaches Similar to Behaviourism? Rather than appeal to the notion of bodily representations, one of the dominant trends in the field of embodied cognition puts emphasis on the explanatory role of action. The volume includes two of its main proponents, **Kevin O'Regan** and **Shaun Gallagher**, who respectively defend an approach to perceptual awareness in terms of sensorimotor laws and to social cognition in terms of sensorimotor skills. However, a frequent objection to sensorimotor approaches is that they fall under the same criticisms as behaviourism faced last century. For example, in his discussion with **O'Regan**, **Ned Block** raises the questions of dreaming and visual imagery with the support of recent experimental evidence that cannot be easily explained in sensorimotor terms. But **O'Regan** seems to escape some of the criticisms by accepting (to some extent) involvement of the brain in his account of qualia. On the other hand, **Daniel Povinelli** explicitly defends a behavioural interpretation of recent evidence in developmental and evolutionary psychology. While his view may seem at first sight closely related to **Gallagher's**, their discussion reveals fundamental disagreements. Both joint papers nicely illustrate the similarities, but also the dissimilarities between sensorimotor approaches and behaviourism.

In addition to foundational issues, the volume covers a wide range of applications of the concept of "embodiment" to several cognitive domains.

Embodied Perception The explanatory role of the body in perception is at the core of both **O'Regan & Block's** paper and **Goldman's** paper. The former focuses more specifically on visual qualia, what it is like to see, but also to imagine or to dream red. Whereas according to **O'Regan**, a red quale (for example) cannot be understood independently of a more holistic experience that is nomologically linked to a set of actions, **Block** conceives of qualia in a more atomistic way, reducible to brain states. On the other hand, **Goldman's** paper focuses on the perception of certain spatial properties, such as distance and slope. **Goldman** reviews recent evidence from Dennis Proffitt's lab to argue in favour of the involvement of off-line motor simulation.

Embodied Concepts Arguments for and against the 'concept empiricist', 'grounded cognition' movement are discussed in the contributions to this volume. **Candidi, Aglioti & Haggard** suggest that somatomotor processes might be phylogenetically and ontogenetically necessary for certain forms of simulation. Similarly, **Weber & Vosgerau** argue for a moderate view, on which motor abilities are a condition on the acquisition of action concepts. In doing so, they develop two simple criteria for taxonomising the sense in which x might be "grounded" by y: x might be a condition for the acquisition of y; or a condition for the constitution of y; or both. Finally **Jacob** presents several conceptual challenges for concept empiricism as a general approach to the nature of concepts, and further evaluates the relationship between computationalism, the embodiment of conceptual processing and the extended mind.

Embodied Self **Candidi, Aglioti & Haggard** describe the sense of body ownership in terms of embodiment$_2$; that is, as a multimodal representation of the body, which is both interoceptive and exteroceptive. **Farmer & Tsakiris**' contribution is more ambitious, they claim to relate two concepts of selfhood, which are too often considered independently: phenomenal selfhood and narrative selfhood. The authors posit a form of bodily self-representation, which arguably bridges the two: a form of body representation that facilitates the subject's experience of itself as an object for both itself and others.

Embodied Social Cognition **Farmer & Tsakiris** present a means of directing future research into the nature of the relationship between subjectivity and intersubjectivity.

They suggest that a form of body representation encoding third-person perspectival information about the subject's own body is deeply tied to one's understanding of others as being able to perceive oneself. However, the most extensive treatment of social cognition can be found in **Gallagher & Povinelli's** discussion. They first contrast their respective views (Enactivism and the Behaviour Abstraction Hypothesis) with alternative views (Theory theory, Simulation theory and Behaviour-rule theory) in the light of recent apparent evidence of mental abilities in young infants and chimpanzees. They then explore the differences between their two views: **Gallagher** emphasises pragmatic, meaningful aspects of our engagement with others; whereas **Povinelli** takes a more computational view that emphasises selection and abstraction of behavioural patterns.

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